

$$\dot{n} = 0.985 \cdot 0.7219 \cdot \frac{0.00456 \cdot 98836}{\sqrt{1 \cdot 0.0287805 \cdot 8.314472 \cdot 378.15}}$$

$$\dot{n} = 33.690 \text{ mol/s}$$

[75 FR 23047, Apr. 30, 2010, as amended at 75 FR 68464, Nov. 8, 2010]

§ 1065.644 Vacuum-decay leak rate.

This section describes how to calculate the leak rate of a vacuum-decay leak verification, which is described in § 1065.345(e). Use Eq. 1065.644-1 to calculate the leak rate, \dot{n}_{leak} , and compare it to the criterion specified in § 1065.345(e).

$$\dot{n}_{\text{leak}} = \frac{V_{\text{vac}}}{R} \cdot \frac{\left(\frac{p_2}{T_2} - \frac{p_1}{T_1} \right)}{(t_2 - t_1)} \quad \text{Eq. 1065.644-1}$$

Where:

V_{vac} = geometric volume of the vacuum-side of the sampling system.

R = molar gas constant.

p_2 = Vacuum-side absolute pressure at time t_2 .

T_2 = Vacuum-side absolute temperature at time t_2 .

p_1 = Vacuum-side absolute pressure at time t_1 .

T_1 = Vacuum-side absolute temperature at time t_1 .

t_2 = time at completion of vacuum-decay leak verification test.

t_1 = time at start of vacuum-decay leak verification test.

Example:

$$V_{\text{vac}} = 2.0000 \text{ L} = 0.00200 \text{ m}^3$$

$$R = 8.314472 \text{ J/(mol} \cdot \text{K)}$$

$$p_2 = 50.600 \text{ kPa} = 50600 \text{ Pa}$$

$$T_2 = 293.15 \text{ K}$$

$$p_1 = 25.300 \text{ kPa} = 25300 \text{ Pa}$$

$$T_1 = 293.15 \text{ K}$$

$$t_2 = 10:57:35 \text{ AM}$$

$$t_1 = 10:56:25 \text{ AM}$$

$$\dot{n}_{\text{leak}} = \frac{0.0002}{8.314472} \cdot \frac{\left(\frac{50600}{293.15} - \frac{25300}{293.15} \right)}{(10:57:35 - 10:56:25)}$$

$$\dot{n}_{\text{leak}} = \frac{0.00200}{8.314472} \cdot \frac{86.304}{70}$$

$$\dot{n}_{\text{leak}} = 0.00030 \text{ mol/s}$$

[73 FR 37327, June 30, 2008]

§ 1065.645 Amount of water in an ideal gas.

This section describes how to determine the amount of water in an ideal gas, which you need for various performance verifications and emission calculations. Use the equation for the vapor pressure of water in paragraph (a) of this section or another appropriate equation and, depending on whether you measure dewpoint or relative humidity, perform one of the cal-

culations in paragraph (b) or (c) of this section.

(a) *Vapor pressure of water.* Calculate the vapor pressure of water for a given saturation temperature condition, T_{sat} , as follows, or use good engineering judgment to use a different relationship of the vapor pressure of water to a given saturation temperature condition:

(1) For humidity measurements made at ambient temperatures from (0 to 100) °C, or for humidity measurements

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made over super-cooled water at ambient temperatures from (–50 to 0) °C, use the following equation:

$$\begin{aligned} \log_{10}(p_{\text{H}_2\text{O}}) = & 10.79574 \cdot \left(1 - \frac{273.16}{T_{\text{sat}}}\right) - 5.02800 \cdot \log_{10}\left(\frac{T_{\text{sat}}}{273.16}\right) + 1.50475 \cdot 10^{-4} \cdot \left(1 - 10^{-8.2969 \cdot \left(\frac{T_{\text{sat}}}{273.16} - 1\right)}\right) \\ & + 0.42873 \cdot 10^{-3} \cdot \left(10^{4.76955 \cdot \left(1 - \frac{273.16}{T_{\text{sat}}}\right)} - 1\right) - 0.2138602 \quad \text{Eq. 1065.645-1} \end{aligned}$$

Where:

$p_{\text{H}_2\text{O}}$ = vapor pressure of water at saturation temperature condition, kPa.

T_{sat} = saturation temperature of water at measured conditions, K.

Example:

$T_{\text{sat}} = 9.5$ °C

$T_{\text{dsat}} = 9.5 + 273.15 = 282.65$ K

$$\begin{aligned} \log_{10}(p_{\text{H}_2\text{O}}) = & 10.79574 \cdot \left(1 - \frac{273.16}{282.65}\right) - 5.02800 \cdot \log_{10}\left(\frac{282.65}{273.16}\right) + 1.50475 \cdot 10^{-4} \cdot \left(1 - 10^{-8.2969 \cdot \left(\frac{282.65}{273.16} - 1\right)}\right) \\ & + 0.42873 \cdot 10^{-3} \cdot \left(10^{4.76955 \cdot \left(1 - \frac{273.16}{282.65}\right)} - 1\right) + 0.2138602 \end{aligned}$$

$\log_{10}(p_{\text{H}_2\text{O}}) = 0.074297$

$p_{\text{H}_2\text{O}} = 10^{0.074297} = 1.186581$ kPa

(2) For humidity measurements over ice at ambient temperatures from (–100 to 0) °C, use the following equation:

$$\log_{10}(p_{\text{sat}}) = -9.096853 \cdot \left(\frac{273.16}{T_{\text{sat}}} - 1\right) - 3.566506 \cdot \log_{10}\left(\frac{273.16}{T_{\text{sat}}}\right) + 0.876812 \cdot \left(1 - \frac{T_{\text{sat}}}{273.16}\right) - 0.2138602 \quad \text{Eq. 1065.645-2}$$

Example:

$T_{\text{ice}} = -15.4$ °C

$T_{\text{ice}} = -15.4 + 273.15 = 257.75$ K

$$\log_{10}(p_{\text{sat}}) = -9.096853 \cdot \left(\frac{273.16}{257.75} - 1\right) - 3.566506 \cdot \log_{10}\left(\frac{273.16}{257.75}\right) + 0.876812 \cdot \left(1 - \frac{257.75}{273.16}\right) - 0.2138602$$

$\log_{10}(p_{\text{H}_2\text{O}}) = -0.798207$

$p_{\text{H}_2\text{O}} = 10^{-0.79821} = 0.159145$ kPa

(b) *Dewpoint.* If you measure humidity as a dewpoint, determine the amount of water in an ideal gas, $x_{\text{H}_2\text{O}}$, as follows:

$$x_{\text{H}_2\text{O}} = \frac{p_{\text{H}_2\text{O}}}{p_{\text{abs}}} \quad \text{Eq. 1065.645-3}$$

Where:

$x_{\text{H}_2\text{O}}$ = amount of water in an ideal gas.

$p_{\text{H}_2\text{O}}$ = water vapor pressure at the measured dewpoint, $T_{\text{sat}} = T_{\text{dew}}$.

p_{abs} = wet static absolute pressure at the location of your dewpoint measurement.

Example:

$p_{\text{abs}} = 99.980 \text{ kPa}$

$T_{\text{sat}} = T_{\text{dew}} = 9.5 \text{ }^\circ\text{C}$

Using Eq. 1065.645-1,

$p_{\text{H}_2\text{O}} = 1.186581 \text{ kPa}$

$x_{\text{H}_2\text{O}} = 1.186581/99.980$

$x_{\text{H}_2\text{O}} = 0.011868 \text{ mol/mol}$

(c) *Relative humidity*. If you measure humidity as a relative humidity, $RH\%$, determine the amount of water in an ideal gas, $x_{\text{H}_2\text{O}}$, as follows:

$$x_{\text{H}_2\text{O}} = \frac{RH\% \cdot p_{\text{H}_2\text{O}}}{p_{\text{abs}}} \quad \text{Eq. 1065.645-4}$$

Where:

$x_{\text{H}_2\text{O}}$ = amount of water in an ideal gas.

$RH\%$ = relative humidity.

$p_{\text{H}_2\text{O}}$ = water vapor pressure at 100% relative humidity at the location of your relative humidity measurement, $T_{\text{sat}} = T_{\text{amb}}$.

p_{abs} = wet static absolute pressure at the location of your relative humidity measurement.

Example:

$RH\% = 50.77\%$

$p_{\text{abs}} = 99.980 \text{ kPa}$

$T_{\text{sat}} = T_{\text{amb}} = 20 \text{ }^\circ\text{C}$

Using Eq. 1065.645-1,

$p_{\text{H}_2\text{O}} = 2.3371 \text{ kPa}$

$x_{\text{H}_2\text{O}} = (50.77\% \cdot 2.3371)/99.980$

$x_{\text{H}_2\text{O}} = 0.011868 \text{ mol/mol}$

[73 FR 37327, June 30, 2008, as amended at 73 FR 59331, Oct. 8, 2008; 75 FR 23048, Apr. 30, 2010]

§ 1065.650 Emission calculations.

(a) *General*. Calculate brake-specific emissions over each applicable duty cycle or test interval. For test intervals with zero work (or power), calculate the emission mass (or mass rate), but do not calculate brake-specific emissions. For duty cycles with multiple test intervals, refer to the

standard-setting part for calculations you need to determine a composite result, such as a calculation that weights and sums the results of individual test intervals in a duty cycle. If the standard-setting part does not include those calculations, use the equations in paragraph (g) of this section. This section is written based on rectangular integration, where each indexed value (*i.e.*, “ i ”) represents (or approximates) the mean value of the parameter for its respective time interval, Δt . You may also integrate continuous signals using trapezoidal integration consistent with good engineering judgment.

(b) *Brake-specific emissions over a test interval*. We specify three alternative ways to calculate brake-specific emissions over a test interval, as follows:

(1) For any testing, you may calculate the total mass of emissions, as described in paragraph (c) of this section, and divide it by the total work generated over the test interval, as described in paragraph (d) of this section, using the following equation:

$$e = \frac{m}{W} \quad \text{Eq. 1065.650-1}$$

Example:

$m_{\text{NO}_x} = 64.975 \text{ g}$